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Technical Report: NAVTRAEQUIPCEN IH-242

ANALYSIS OF ACOUSTIC SYNTHESIZERS FOR PASSIVE SONAR SIMULATION

Electronics and Acoustics Laboratory
Naval Training Equipment Center
Orlando, Florida 32813

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NAVAL TRAINING EQUIPMENT CENTER
ORLANDO, FLORIDA 32813

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ANALYSIS OF ACOUSTIC SYNTHESIZERS FOR PASSIVE SONAR SIMULATION

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This report provides a summary of acoustic synthesizers that are either integral parts of ASW training devices, or function as research tools to create target spectra information. Questionnaires were submitted to users and designers of passive sonar acoustic synthesizers. The forms were returned to the Naval Training Equipment Center and then organized into the form of a Device Comparison Chart, Table 1. The table is designed to provide information in the way of specification data so that comparisons and

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evaluations of these synthesizers may be made in related studies.

The results showed many basic similarities for the acoustic synthesizers, e.g., multiple target presentation, variable target types, ocean modeling and spectrum control.

A recommendation is made to investigate the possibility of developing an acoustic synthesizer that would be adaptable for all passive sonar training.

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INTRODUCTION

ACOUSTIC SIMULATION

No systematic study has been performed recently to summarize the different acoustic synthesizers that are being used for passive sonar operator training in the skills of target detection, tracking, classification, and identification. The performance characteristics requirements for these target acoustic synthesizers vary with:

a. The sonar to be simulated

b. The ocean area that is to be used

c. The technical background of the individual designing the synthesizer.

Many of the acoustic synthesizers are an integral part of trainers that are being used for team tactical training and represent a small part of the complete trainer. The cost of this portion of the trainer is difficult to assess, but a well rounded guess would be about 50,000 to 100,000 dollars. The acoustic target synthesizer provides the sonar operator trainee with a spectrum of the target signature characteristics. Figure 1 is a block diagram of a typical synthesizer that shows the various noises that would make up a final target signature. This stimuli is processed in the sonar unit and activates the various displays and indicators, both aural and visual. Analog and/or digital stimulation control have been used depending on whether:

a. The signal is fed into the sonar processors, which would analyze the analog signal and then display it, or

b. The processor is bypassed and the digitally controlled input signal now fed directly into the displays.

Both methods are presently being used, and it was found that there are arguments, pro and con, for both techniques.

Though it is not the purpose of this report to analyze the acoustical data used in target synthesis, a brief synopsis of the components that make up the target characteristics is presented.

SOUND CLASSIFICATION

Sounds making up the acoustic environment are classified by their sources as follows:

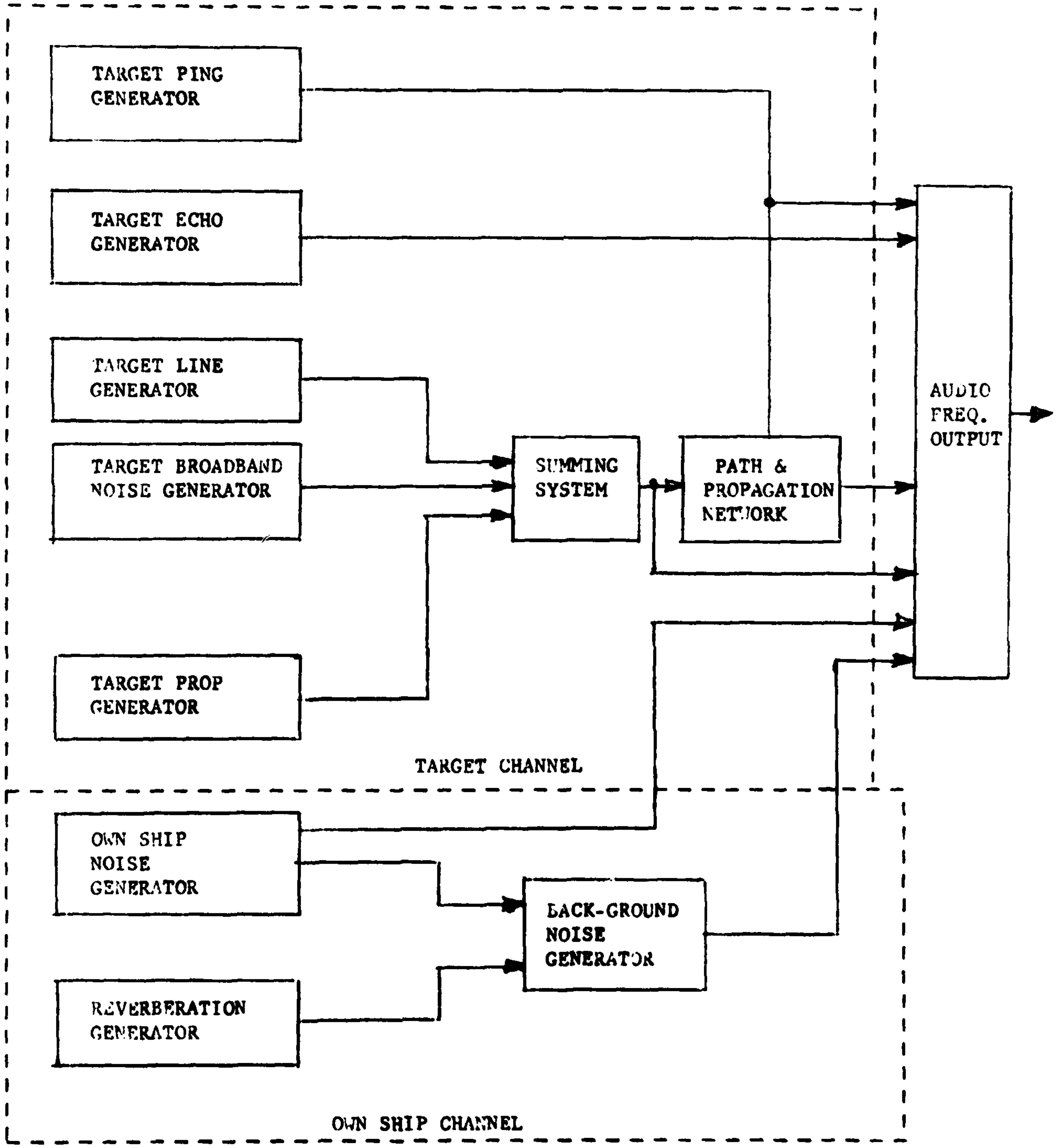

Figure 1. Typical Synthesizer Block Diagram

a. Radiated Ship-Noise

(1) Hydrodynamic flow noise

(2) Propellor cavitation noise

(3) Various distinct line spectra produced by propulsion and auxiliary machinery

Target radiated noise and echoes are a function of target type, motion, depth, and ocean effects.

b. Ships Self-Noise

(1) The same general features as radiated ship noise

(2) Reverberation of the transmitted sonar pulse

Own-ship noise is a function of own-ship motion and depth. When the own-ship is actively echo ranging, reverberations are a function of pulse width, thermal layer depth, and own-ship depth.

c. Marine Ambient Noise

(1) Non-directional: background noise generated by wave action

(2) Directional: various sound characteristics caused by marine life.

Marine life noise is introduced as either omni-directional or directional signals. Directional marine life noise is attenuated as a function or range and thermal layer depth.

Sea state noise can be introduced by the sonar program operator who has the capability of entering sea states ranging from a calm sea to a rough sea, or may be a computer controlled input.

SECTION II

STATEMENT OF THE PROBLEM

Many acoustic synthesizers presently exist and are being used as integral parts of sonar trainers and research tools. It is the purpose of this report to list the various characteristics of the passive sonar acoustic synthesizers. This data may result in savings of time, money, and improved training technology, in future designs of acoustic synthesizers.

SECTION III

PROCEDURE

DESCRIPTION OF SURVEY

Data for this study was obtained by means of an in-depth literature survey on acoustic synthesizers for passive sonars. All available data sources were used to identify past, current, and near future synthesizers. The data sources are as follows:

a. Source: IR&D Reports, DDC Report No. IR 1164
Method of Access: Computer Search, March 1974 (U)
Extent of survey: Twenty-two reports were studied with a large percentage from Hughes and Raytheon. Contacts with their technical people showed that most of their acoustic signatures are obtained from magnetic tapes.

b. Source: Research and Development Planning Summaries, DDC Report No. PP1041
Method of Access: Computer Search, March 1974 (S)
Extent of Survey: Twenty-three Form 1634's were studied. One contact was made with ONR Undersea Program Office, but the information was identical with the DD 1498 Work Unit Plans.

c. Source: Work Unit Management Information Systems, DDC Report No. T21070
Method of access: Computer Search, March 1974 (C)
Extent of Survey: Thirty-three Form 1498 Work Unit Plans were studied. This information led to several contacts with various government organizations.

d. Source: Study by TAEG, Naval Training Equipment Center (reference 7), see Appendix A.

e. The above data was supplemented for facilities that had an acoustic synthesizer which could relate to this survey by means of a questionnaire. The questionnaire form in Appendix B was sent for accomplishment and to be returned to the Naval Training Equipment Center. The form consists of pertinent questions relating to characteristics of acoustic synthesizers used for passive sonar target synthesis.

The questions request the following information:

a. Items 1, 2, and 3. The name of the device, the year it was built, for whom, and the purpose and description of the device.

b. Items 4 and 5: The type of control used for the input to the synthesizer, and defines whether the output of the synthesizer is feeding into the sonar processor or goes directly to the aural and visual displays.

c. Items 6a, 6b, and 6d: Supply answers for target detail, i.e., amount, types, and whether multiple targets can be presented simultaneously

d. Items 6c and 6e. The number of discrete frequencies available for target signature synthesis and defines characteristics and resolution of these lines

e. Items 7 and 8: The types of weapons and noises that are simulated for each device.

f. Items 9 and 10: The type of ocean math model that is used and defines the oceans that are represented for each synthesizer.

g. Item 11: The sonars that are to be simulated or stimulated by each synthesizer. The associated operational frequencies are readily available and can be found in classified documents relating to these sonars (references 1 through 6).

This information was consolidated into the Device Comparison Chart of Table 1. The chart does not attempt to show the worst case or the best, but does attempt to detail the characteristics that are considered to be of importance for passive sonar target synthesis by each designer/user of the device.

SECTION IV

RESULTS/DISCUSSION

The Device Comparison Chart, Table 1, is a digest of the data contained in Appendix C that was orginated for each synthesizer. The synthesizer characteristics represent two basic subsystems; the target generation, and the propagation loss for the respective oceans. The information as shown consists of the following categories with the explanations of these categories described in Section III of this report.

a. Input/Output Control: The state-of-the-art advances in acoustic simulation technology have led to the development of training devices which use digital and hybrid techniques for the generation of acoustic signals. The output signals are digital if they are energizing simulated sonar displays, or they are analog if they are stimulating operation (actual) sonar components which would be integral parts of the trainer.

b. Target Information/Weapons Simulated: types, quantity, and multiple: Acoustical data can be obtained from reference 8 on the targets and weapons that are listed below. The number of signatures used in the synthesizers depend on the size and complexity of the trainer.

TABLE 1. DEVICE COMPARISON CHART

ACOUSTIC SYNTHESIZER CHARACTERISTICS

Synthesizer	Input Analog/Digital/Hybrid	Output Analog/Digital/Hybrid	Amount of Targets	Multiple Target Presentation	Amount of Discrete Frequencies (Lines)	Line Amplitude (DB)	Resolution (DB)	Line Width (HZ)	Resolution (HZ)	Amount of Weapons	Propagation Loss Model
2F66	D	A	3	Yes	(Any variable freq, & width)				0.01	2	Computer Math Model
2F69D	H	H	3	Yes	100	0-130	1	-	-	2	16 Sound Loss Curves
2F92	D	A	-	-	30	(Computer controlled)				3	Data is provided
14B44	H	H	4	Yes	300	0-127	1	0.2-3.1	0.2	2	Derived from ASWEPS Data
2F106	D	A	-	Yes	(Not for Target Classification)					2	ASRAP
2F87T	H	A	4	Yes	300	0-63	1	0.2-24	-	2	16 Sound Loss Curves
14E19	D	D	Team Trainer with Programmable Input								
14E23	D	D	"	"	"	"		"			
14E24	D	D	"	"	"	"		"			
21A38	H	A	15	6	20	0-75	1	0.15-12	0.05	6	Fixed Networks
21A39/2	H	A	9	6	10	(Computer Controlled)				-	AMOS
CME	H	A	16	Opt.	70	0-127	1	0.2-1030	0.1	Opt.	Specified by Customer
GNATS	H	A	-	Opt.	48	-10 to +1-	1	Variable		-	Used at Sea
DASS	D	A	-	Opt.	105	1-43	1.5	Variable		-	Used at Sea
21A40	D	A	12	Yes	12	0-75	1	0.15-12	0.05	6	FACT

1.	U. S. Diesel Sub	11.	Freighter
2.	Foreign Diesel Sub	12.	Cruiser
3.	U. S. Nuclear Sub	13.	Destroyer Escort
4.	Foreign Nuclear Sub	14.	Aircraft
5.	Snorkeling Sub	15.	Hydrofoil
6.	Surfaced Sub	16.	Countermeasures
7.	Merchant Ship	17.	Mines
8.	Patrol Boats	18.	Depth Bombs
9.	Destroyer	19.	Rockets
10.	Fishing Boat	20.	Various Torpedoes

More explicit data can be obtained in references 8 and 9. These two references state that an acoustic synthesizer that contains these signatures, and having a capability of multiple presentation, is desirable in training situations.

c. Target Spectrum Information: resolution, amplitude/frequency control: The noise spectra radiated by targets consists of two basic types:

(1) Broadband noise that has a continuous spectra.

(2) Narrow band noise that consists of sets of line components, where each set contains all lines in a harmonic family. The most important characteristics for classification in a narrow band noise were found to be:

(a) Line strength - a function of speed and depth

(b) Line width - defines the energy contained in the tonal bandwidth.

(c) Line stability - phase or frequency modulation: The quantity of lines (in this analysis) are important clues for final classification. The width of each line must be incremently variable for further cues, along with its resolution and amplitude. This information is dependent on the target and the sonar processor and at the present time, varies with each acoustic synthesizer (reference 1, 2, 3, 5, and 6). A recent proposal for a sonar operational trainer by the Naval Underwater Systems Center (reference 9) has a total of 50 tonal lines. More detailed information can be obtained in this reference. Further classified information relating to line strength, line width, and line stability can be obtained from reference 8.

d. Oceans Represented and Propagation Loss Math Model: Each synthesizer simulated oceans dependent upon the geographic location of where the training was to be accomplished. The propagation math model was variable, except for the NUSC synthesizers, GNATS and DASS, which were designed to be used at sea.

SECTION V

CONCLUSIONS

Findings of this survey support the premise that there are basic similarities for the various synthesizers, e.g., multiple target presentation, variable target types, ocean propagation loss modeling, and spectrum control for target signature synthesis. The results of this survey would indicate the following:

a. Multiple target presentation is desirable.

b. Ocean modeling should have the flexibility of being programmable for the acoustic synthesizer and would be dependent on the user.

c. Tonal line control should be capable of meeting spectrum analyzer resolution. The amount of lines for a signature is variable, but the incremental amplitude control, width, and modulation control for an acoustic synthesizer should be as good as the processor. Detailed information on spectra resolution can be obtained in reference 8.

SECTION VI

RECOMMENDATIONS

This survey has shown that there is a wide variation in passive sonar acoustic synthesizer technology.

A recommendation would be that it may be possible to develop an acoustic synthesizer that would be adaptable for all passive sonar training. This would involve the following:

a. Determine which method of input control, analog or digital, would be more practical. The present state-of-the-art defines digital control as being more predictable than analog control.

b. Determine the "training versus cost" effectiveness of using government furnished components of operational sonars as an integral part of the acoustic synthesizer or to simulate the sonar processor and the displays.

c. Determine the amount of information in the target spectra that is required for improving training techniques.

To finalize, it is recommended that the facility containing the Countermeasures Evaluator (CME) in use at the Naval Coastal Systems Laboratory, Panama City, Florida, should be studied as a comparison for a passive sonar facility for the Naval Training Equipment Center. The CME can use any ocean specified, can introduce multiple targets, and has the capability of varying discrete frequency lines in both amplitude and resolution. The facility does not have the capability for testing and evaluating new synthesizer technology and training effectiveness. An improved facility would allow for:

Investigation of trainee performance measurements.

Testing and verifying technology for new concepts in trainers for better training effectiveness.

Investigation of the amount of spectra information in the acoustic signature that is critical in training.

REFERENCES

1. NAVSO P-2098-2, 2 November 1967, Acoustic Simulator Maintenance Handbook, Device 21A39/2, NAVTRADEVCEN (C)

2. NAVSO P-2098-5, April 1967, Equipment Maintenance Handbook, Device 21A39/2, NAVTRADEVCEN (C)

3. NAVSO P-2097, July 1967, Operators Guide for Sonar Room Tactical Team Trainer, Device 21A39/2, NAVTRADEVCEN (C)

4. SSBN Sonar System and SS/SSN Sonar System, Volumes 1 and 2, NAVSHIPS (C)

5. NAVO P-3202-1, May 1962, Maintenance Handbook for AN/BQQ-2 Sonar Simulator, Device X21A38/2, NAVTRADEVCEN (C)

6. NAVTRADEVCEN P-3726-1, Maintenance Handbook for ATT Sonar Simulation NAVTRADEVCEN

7. TAEG-NAVTRAEQUIPCEN, Orlando, Florida, January 1974, Generalized Acoustic Sensor Operator Trainer SS74-1, (pp 28-35)

8. NAVSHIPS, 1971, Principles of Lofargram Analysis, Human Factors Research, Inc. (S)

9. NUSC, January 1973, Target Modeling Study for the Sonar Operator Trainer (S)

APPENDIX A

Historical Development of Synthesizer Techniques (Reference 7)

Appendix A contains a summary of simulation techniques that have been used over a period of years. It also contains Table 2, Summary of Devices, and Table 3, Survey of Acoustic Simulation. This appendix provides a brief history of acoustic sonar technology to present the progress that has been made throughout the years in attempting to synthesize acoustic signals for passive sonar detection training. The information of the various capabilities and limitations for each technology helped to shape each future technology in target simulation and portrays state-of-the-art progression in the acoustic sensor training equipment design.

Rooftop Transmitters: 1955-1967 (Air ASW Only)

Description

A series of trainers, known as "rooftop trainers" were developed. These trainers used a transmitter and an antenna to send acoustics information to aircraft flying in the vicinity. In many cases, the transmitter and antenna portions of an actual sonobuoy were used. Simulated submarine propeller beats were electronically generated, immersed in noise, and superimposed upon a radio-frequency (RF) carrier to be transmitted to the sonobuoy receiver in the aircraft. This type of trainer is also utilized, by eliminating the RF link, with the operational acoustic recorder in a classroom training situation. The simulated sea noises in which signals were immersed were generally tape recordings of actual sea sounds because artificial generation of such sea noises was judged to be unrealistic.

Capabilities/Limitations (C/L)

(C) Can be utilized as a maintenance aid in pre-flighting equipment.

(C) Can be utilized as a team trainer in aircraft situation or as individual trainer in classroom situation.

(L) FCC regulations prohibit unrestricted operation since bonobuoy transmitter frequencies interfere with standard communication networks.

(L) Team training in aircraft is expensive.

Tape Recorder/Playback Units: 1958 - 1965

Description

Magnetic tape recording equipment was utilized to record sounds generated under operational situations. That is, actual submarine and surface vessel sounds received by sonar, sonobuoy, or dipped sonar equipment are

recorded on magnetic tape and annotated by the proper government agencies. These recordings are then edited and distributed to trainees utilizing operational acoustic processing equipment in schools and at sea. The tape editing capability includes the provision for recording narrative to improve the instructional capability.

Capabilities/Limitations

(C) Taped sounds are realistic.

(L) Generation of tapes is costly as it involves coordinated activities of submarines, surface vessels and aircraft.

(L) Taped simulation in non-dynamic, i.e., problem progression is not under instructor control.

Analog Signal Simulators: 1959 - 1965

Description

A group of tactics/weapon system trainers were developed which used analog simulation techniques to generate underwater sounds. These trainers contained a group of sinusoidal signal generators to represent individual chracteristics of targets, i.e., fundamental frequency of propeller, number of propellers, pumps, etc. These are individually adjustable by instructor control. Signals are summed, immersed in noise and routed to the operational acoustic processor under trainee control. The generation of background noise was generally considered unrealistic unless tape recording of actual sea noise were utilized.

Capabilities/Limitations

(C) Simulation is dynamic

(C) Relatively inexpensive as compared to utilization of operational equipment

(L) Analog hardware is expensive to duplicate as compared to digital software and more difficult to maintain.

(L) Difficult to modify in response to new or updated operational equipment

Digital/Hybrid Signal Simulators: 1968-1973

Description

Recent state-of-the-art advances in underwater simulation have led to the development of a series of training devices which use digital and hybrid techniques for the generation of acoustic signals. The acoustic spectrum is defined in the frequency domain by digital information (words) representing the relative strength and frequency of each discrete component in the spectrum. By a digital processing techniques known as the Inverse Fast Fourier Transform (IFFT), this digital data is transformed into a composite signal (time domain) characteristic of the acoustic signal. This signal is then directed to the operational equipment for analysis and processing. This simulation technique is the converse of the process performed by the latest operational acoustic processing equipment wherein an acoustic signal (time domain) is received, digitized, analyzed by an FFT processor and outputted as being composed of a sequence of discrete frequency components (frequency domain information). Another method of digital simulation is implemented by having a stored sine table resident in computer memory which is sampled at a rate representing the desired frequency. Generally, some form of analog generated background noise is added to this signal to provide realism.

Capabilities/Limitations

(C) Simulation is dynamic.

(C) Digital software inexpensive to duplicate, modify, and maintain.

(L) Development costs are high due to amount of programming required.

Tables 2 and 3 provide a concise overview of the existing acoustic training devices, the year procured, quantities and a brief acoustic related description.

TABLE 2. SUMMARY OF DEVICES

PROCUREMENT YEAR \ DEVICE TYPE	AIR ASW: ROOFTOP TRANSMITTER	AIR ASW: TAPE RECORDER/ TRANSMITTER	AIR ASW: ANALOG SIGNAL SIMULATION	AIR ASW: DIGITAL/HYBRID SIGNAL SIMULATION	SURFACE ASW: TAPE RECORDER/ PLAYBACK	SURFACE ASW: ANALOG SIGNAL SIMULATION	SURFACE ASW: DIGITAL/HYBRID SIGNAL SIMULATION	SUB-SURFACE ASW: TAPE RECORDER PLAYBACK	SUB-SURFACE ASW: ANALOG SIGNAL SIMULATION	SUB-SURFACE ASW: DIGITAL/HYBRID SIGNAL SIMULATION	
1973							14E23			21A40	
1972							14E24				
1971				2F92							
1970				14B44							
1969							14E19				
1968				2F87(T)							
1967	14B35										
1966			21B12			21B12			21B12		
1965			14E7A		14E15						
1964			2F64		14E14						
1963		14E10			14E12				21A39		
1962			2F69								
1961	14B22	14B15	14E7					21B55	21A38		
1960	14B21	14B12	2F71		14E3						
1959	14B19		2F66		14E6						
1958	15M13				14E1						
1955	15M12B										

TABLE 3. SURVEY OF ACOUSTIC SIMULATION

DEVICE	YEAR	QUANTITY	DESCRIPTION - ACOUSTIC RELATED
2F64	1964	2	Dipping sonar of SH-3A helicopter. Analog stimulation of operational equipment.
2F64A	1965	3	Dipping sonar of SH-3(HS) helicopter. Analog stimulation of AQS-13 and AQS-13A sonars.
2F66	1958	1	S-2D ASW mission WST. Analog simulation.
2F66A	1964	3	S-2E(VS) ASW mission WST. Analog simulation.
2F66C	1964	1	S-2E(VS) ASW mission WST. Analog simulation.
2F69	1961	1	P-3 (VP) series aircraft. ASW mission WST. Analog simulation.
2F69A	1962	1	P-3 (VP) series aircraft. ASW mission WST. Analog simulation.
2F69B	1963	3	P-3 (VP) series aircraft. ASW mission WST. Analog simulation.
2F71(T)	1959	7	SP-2E/H (VP) ASW Tactical Team Trainer. Analog simulation.
2F87(T)	1968	2	P-3C (VP) ASW Tactical Team Trainer. Digitally controlled analog stimulation of operational equipment.
2F92	1971	1	S-3A Weapon System Trainer. Digitally generated signals - stimulation of operational equipment.
14B12	1960	30	VP-VS Julie Operator Trainer. Tape playback unit into ASA - 20/26 Julie recorder.
14B15	1960-69	38	VP-VS Jezebel Operator Trainer. Tape playback unit into AQA-4 or AQA-5 recorder via ARR-52 Sonobuoy receiver.
14B19A	1951	191	Airborne Julie Trainer. Julie signal generator fed into Julie recorder via Sonobuoy receiver.
14B19B	1961	4	Classroom version of Device 14B19A.
14B21	1960	133	Jezebel Target Simulator. Device provides Codar/Lofar info and transmits to Sonobuoy receiver.

TABLE 3. SURVEY OF ACOUSTIC SIMULATION (Cont)

DEVICE	YEAR	QUANTITY	DESCRIPTION - ACOUSTIC RELATED
14B22	1961	3	Julie attachment to 15M13 Sonobouy flight trainer (Roof Top).
14B35	1967	2	Julie/Jezebel Operator Trainer - Roof Top - can also be utilized in classroom by tapping off signal before antenna.
14B44	1970	2	Difar Operator Trainer. Multi-station digital generation of acoustic signals.
14E1	1958	1	Sonar tape recorder.
14E3	1960	2	Sonar tape playback unit.
14E6	1958	1	Sonar tape Editor/Duplicator.
14E7	1961	4	AQS-10 Airborne Sonar Classroom Trainer. Sonar signals synthetically generated (SH-3A)(HS)
14E7A	1966	1	Same as Device 14E7 but uses tapes for ambient noises.
14E10	1963-64	11	AQS-10/13 Helo Sonar Type playback series.
14E12	1963	5	Sonar Tape Recorder/Playback for SQS-26 sonar.
14E14	1964	1	Sonar-tape Playback unit with 5 trainee stations.
14E15	1965	1	Sonar-tape Editor/Reproducer Playback unit.
14E19	1969	8	SQS-26 Sonar Operator/Team Trainer. Digital signal simulation feeds operational sonar set.
14E23	1973	1	SQS-35 Sonar Modular Addition to 14A2. Digital simulation of sonar signals.
14E24	1972	1	SQQ-23 (Pair)Sonar Operator Trainer. Digital signal simulation.
15M12B	1955-56	45	Rooftop mounted sonobouys transmit taped noise and beat generator signals to aircraft.
15M13	1958	16	Rooftop sonobouy simulator.
21A38	1961	1	Submarine ASW Training Facility, Analog simulation.
21A39	1963	1	Fleet Ballistic Missile Team Trainer. Analog simulation.

TABLE 3. SURVEY OF ACOUSTIC SIMULATION (Cont)

DEVICE	YEAR	QUANTITY	DESCRIPTION - ACOUSTIC RELATED
21A40	1973	1	Submarine Attack Trainer. Digital generated signals stimulate operational equipment.
21B12	1966	80	ASW Submarine Target (miniaturized).
21B55	1961	5	Tape recorder/playback into operational sonar set.

Appendix B

ACOUSTIC SYNTHESIZER STUDY, SAMPLE SHEET

1. Device ______________________________

2. Year ______________________________

3. Description ______________________________

____

4. Input Control: Analog ( ) ______________

Digital ( ) ______________

Both ( ) ______________

5. Output data: Analog ( ) ______________

Digital ( ) ______________

6. Target Information: ______________________

a. Number of targets ______________________

b. Are multiple targets available? ______________

c. Number of discrete frequencies. (Lines) ______________

d. List types of targets.

1.	______	5.	______	9.	______
2.	______	6.	______	10.	______
3.	______	7.	______	11.	______
4.	______	8.	______	12.	______

e. Define line control (amplitude & frequency resolution.

____

____

____

7. List weapons simulated.

1.	____________	4.	____________	7.	____________
2.	____________	5.	____________	8.	____________
3.	____________	6.	____________	9.	____________

8. List noises simulated.

1.	____________	4.	____________	7.	____________
2.	____________	5.	____________	8.	____________
3.	____________	6.	____________	9.	____________

9. Oceans represented.

1.	____________	3.	____________	5.	____________
2.	____________	4.	____________	6.	____________

10. Define math model of propagation loss.

____

____

____

11. List Sonar Systems and various displays.

____

____

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APPENDIX C

ACOUSTIC SYNTHESIZER STUDY, DETAILS

Appendix C contains the questionnaire replies relating to the individual target synthesizers and also the pertinent data. These forms had been sent to the technical personnel directly involved with the design or the original specifications.

ACOUSTIC SYNTHESIZER STUDY

1. **Device** 2F66D
2. **Year** 1973
3. **Description** S2G Weapon Systems Trainer, provides crew and operator training for AQA-7
4. **Input Control:** **Analog** ( ) \
   Digital (X) \
   Both ( )
5. **Output data:** **Analog** (X) \
   Digital ( )
6. **Target Information:**
   a. **Number of targets** 3
   b. **Are multiple targets available?** Yes (3)
   c. **Number of discrete frequencies. (Lines)** 16 Fundamental
   d. **List types of targets.**

1.	Nuclear Sub	5.		9.	
2.	Convoy	6.		10.	
3.	Destroyer	7.		11.	
4.		8.		12.	

   e. **Define line control (amplitude & frequency resolution.**

1. Amplitude - 256 steps over 48 DB range.
2. Frequency - resolution of 2 microseconds.
3. Lines may be produced every 0.01 HZ over range.
4. Lines have variable frequency and width.
5. Line characteristics may be a function of any set of parameters associated with the target dynamics.

7. **List weapons simulated.**

1. Torpedo	4.	7.
2. Depth Charges	5.	8.
3.	6.	9.

8. **List noises simulated.**

1. Marine Life	4. Hydroplane	7.
2. Torpedo running	5.	8.
3. Convoy	6.	9.

9. **Oceans represented.**

1. Mediterranean	3. South of Greenland	5.
2. Caribbean	4.	6.

10. **Define math model of propagation loss.**

Sound loss profile from computer math model of actual area. Stored in read-only-memories.

11. **List Sonar Systems and various displays.**

SSQ-36

SSQ-41

SSQ-47

SSQ-53

All displayed on the AQA-7

1. Device 2F69D, P-3A, Weapon System Trainer
2. Year Started 1961
3. Description P-3 Orion ASW Crew Trainer
   Flight - Pilot/Co-Pilot; Tactics - TACCO/MAD-Radar Navigator/DIFAR
4. Input Control: Analog (X) Flight
   Digital (X) Tactics (DDP-516)
   Both ( )
5. Output data: Analog (X) Flight
   Digital (X) Tactics
6. Target Information:
   a. Number of targets 3
   b. Are multiple targets available? Yes
   c. Number of discrete frequencies. (Lines) 100 Lines/Target, 300 lines possible
   d. List types of targets.

1. Diesel Sub (U.S. or Soviet)	5.	9.
2. U.S. Nuclear Sub	6.	10.
3. Soviet Nuclear Sub	7.	11.
4. Merchant	8.	12.

   e. Define line control (amplitude & frequency resolution.
   1. 50/300/850/1700 HZ - 0 to 130 DB (1 DB Increments)
   2. Shear Current (Amplitude: 0-7) (Bandwidth: 0-63)
   3. Artifacts (Amplitude: 0-7) (Freq. : 0-2400 HZ (1 HZ Increment))
   4. Pinnacle Size: Small, Medium, Large
   5. Background Amplitude: +10 to -64 DB (1 DB Increments)

7. **List weapons simulated.**

1. MK-44 Torpedo	4.	7.
2. MK-46 Torpedo	5.	8.
3.	6.	9.

8. **List noises simulated.**

1. Sea-State (Back-Ground) (Wash-Over) (Water Gargle)	4. Hydrophone (Lowering) (Hung)	7. Power Plant (1-2 Engines) (in/out of Sync)
2. Diesel/Turbine	5. Sonobuoy (1. Intermittent RF) (2. Noisy Battery)	8. Propeller (Cavitation) (Beat) (Singing)
3. Biological (Porpoise) (Whales) (Snapping Shrimp)	6. Non Power Plant (pumps, etc.)	9. Torpedo & Aircraft

9. **Oceans represented.**

1.	3.	5.
2.	4.	6.

10. **Define math model of propagation loss.**

Temperature Profile Data (Temp/Depth Break-points)

16 - Sound Loss Curves (Range/Loss Break-points)

Sea-States (0-4), Bottom Type (0-5)

11. **List Sonar Systems and various displays.**

SSQ-36	B.T.
SSQ-41	LOFAR
SSQ-47	RO
SSQ-53	DIFAR

ACOUSTIC SYNTHESIZER STUDY

1. Device 2F92 S-3 Weapon System Trainer
2. Year #1 Delivered March 1974
3. Description Flight & Tactics Simulation

4. Input Control: Analog ( )
   Digital (x)
   Both ( )
5. Output data: Analog (x)
   Digital ( )
6. Target Information:
   a. Number of targets
   b. Are multiple targets available?
   c. Number of discrete frequencies. (Lines) 30
   d. List types of targets.

1.	Surface Ship	5.		9.	
2.	Pinnacle	6.		10.	
3.	Submarine (Tapes)	7.		11.	
4.		8.		12.	

   e. Define line control (amplitude & frequency resolution.

Not simulated. Up to 30 Voltage audio signals in voltage analog form are presented to the Acoustic Data Processor (GFP), and hence to aircraft displays

7. **List weapons simulated.**

1. MK-46 MOD 0	4.	7.
2. MK-46 MOD 1	5.	8.
3. MK-54 Depth Bombs	6.	9.

8. **List noises simulated.**

1. Torpedo running sounds	4. Rain	7. Turbines, Engines
2. Ambient Sea-State	5. Singing props	8. Cavitation
3. Shrimp	6. Distant Shipping	9.

9. **Oceans represented.**

1. Any desired - (An "ocean 3. kit" procedure is suppl 5. ied.

2.	4.	6.

10. **Define math model of propagation loss.**

Accomplished with "stored" tables defining propagation loss profiles for various ocean parameters.

11. **List Sonar Systems and various displays.** (Sonobuoys)

SSQ-41 LOFAR

SSQ-53 DIFAR

SSQ-47 RO

SSQ-50 CASS

SSQ-62 DICASS

SSQ-36 BT

AN/ARR-76 Radio Receiving Set (SRT)

Multi-Purpose Display and Auxiliary read-out.

ACOUSTIC SYNTHESIZER STUDY

1. **Device** 14B44, P3-C, Aircraft
2. **Year** 1971, Patuxent River, Md. (1st of 4 Units)
3. **Description** Replica of DIFAR operators stations for P3-C & provides training for AQA-7 system
4. **Input Control:**
   - Analog ( )
   - Digital ( )
   - Both (X)
5. **Output data:**
   - Analog (X)
   - Digital (X)
6. **Target Information:**
   - a. **Number of targets** 4
   - b. **Are multiple targets available?** Yes
   - c. **Number of discrete frequencies. (Lines)** 300
   - d. **List types of targets.**

1. Diesel Electric	5.	9.
2. Nuclear Sub	6.	10.
3. Merchant Vessel	7.	11.
4. Pinnacle	8.	12.

   - e. **Define line control (amplitude & frequency resolution.**

     Discrete frequency lines vary as a function of target speed, depth 7 aspect.

     Source level: 0-127 db in 1 DB increments

     Line Width: 0.2-3.1 HZ in 0.2 HZ increments

7. **List weapons simulated.**

1.	Mine	4.		7.	
2.	Torpedo	5.		8.	
3.		6.		9.	

8. **List noises simulated.**

1.	Biological sounds	4.		7.	
2.		5.		8.	
3.		6.		9.	

9. **Oceans represented.** Programmable for any Fleet Weather Service available ocean.

1.		3.		5.	
2.		4.		6.	

10. **Define math model of propagation loss.**

64 point plot of any given acoustic propagation loss curve

11. **List Sonar Systems and various displays.**

SSQ-53 Passive buoy

SSQ-47 Active

SSQ-50 Command Active Sonobuoy System

AQA-7 Consists of CRT & GRAMS

ACOUSTIC SYNTHESIZER STUDY

1. **Device** 2F106, Trainer NTEC
2. **Year** 1975 - NAS, Norfolk
3. **Description** provides training for Light Airborne Multi-Purpose System (LAMPS) on the SH-2D Helicopter Weapon System
4. **Input Control:**
   - Analog ( )
   - Digital ( )
   - Both (X)
5. **Output data:**
   - Analog (X)
   - Digital ( )
6. **Target Information:**
   - a. **Number of targets** NA
   - b. **Are multiple targets available?** Yes
   - c. **Number of discrete frequencies. (Lines)** NA
   - d. **List types of targets.**

1.	Subs	5.	Fishing boat	9.	
2.	Patrol Boat	6.	Freighters	10.	
3.	Destroyer	7.		11.	
4.	Aircraft	8.		12.	

   - e. **Define line control (amplitude & frequency resolution.**

Target line noise characteristics include a very gross simulation of audio responses to target parameters. The ASA-26B recorder is not used for target classification. All target data is data-linked to own ship CIC Station. This is not simulated.

7. **List weapons simulated.**

1.	MK-46 Torpedo	4.		7.	
2.	MK-44 Torpedo	5.		8.	
3.		6.		9.	

8. **List noises simulated.**

1.	Marine life	4.	Aircraft noises	7.	
2.	Geological noises	5.	Variable Sea-states	8.	
3.	SSQ-41/47B Sonobuoys	6.		9.	

9. **Oceans represented.**

1.	Atlantic	3.		5.	
2.	Pacific	4.		6.	

10. **Define math model of propagation loss.**

Stored information ased on ASREP data

11. **List Sonar Systems and various displays.**

AN/ARR 52B Receiver

AN/ASA 26 Recorder

ACOUSTIC SYNTHESIZER STUDY

1. Device 2F87(T), P3-C, Weapons System Trainer (Tactics)

2. Year 1971 (4 units)

3. Description Fixed base, completely computerized replica of P3-C aircraft with trainee positions for TACCO, NAV/COM, & sensors

4. Input Control: Analog ( )
   Digital ( )
   Both (X)

5. Output data: Analog (x)
   Digital ( )

6. Target Information:

   a. Number of targets 4

   b. Are multiple targets available? Convoy plus 3 individual targets

   c. Number of discrete frequencies. (Lines) 300

   d. List types of targets.

1. Diesel Electric	5.	9.
2. Nuclear Sub	6.	10.
3. Merchant Vessel	7.	11.
4. Pinnacle	8.	12.

   e. Define line control (amplitude & frequency resolution.

   Discrete frequency lines vary in amplitude and frequency as a function of target speed and aspect angle. Level variable 0-63 db in 1 db increments. Line width 0.2-24 HZ

7. **List weapons simulated.**

1.	Mine	4.		7.	
2.	Torpedo	5.		8.	
3.		6.		9.	

8. **List noises simulated.**

1.	Active ranging	4.	Weapon detonation	7.	
2.	Passive ranging	5.	Sonobuoy sounds	8.	
3.	Background noises	6.	Biological sounds	9.	

9. **Oceans represented.** Programmable for any ocean.

1.		3.		5.	
2.		4.		6.	

10. **Define math model of propagation loss.**

64 point plot of any given acoustic propagation loss curve. To define a given ocean area requires 16 curves consisting of 4 curves for each of 4 frequencies.

11. **List Sonar Systems and various displays.**

SSQ-47 Active

SSQ-53 Passive

SSQ-50 Command Active Sonobuoy System (CASS)

Displays consist of CRT & GRAMS

ACOUSTIC SYNTHESIZER STUDY

1. **Device** /Facility 21A38 Trainer, NTEC
2. **Year**/Destination 1962/Pearl Harbor
3. **Description** Provides sonar room tactical team with conditions simulating those encountered aboard SSN 578, SSN 594 and SSBN 616 classes.
4. **Input Control:** **Analog** ( ) **Digital** ( ) **Both** (X) Much of the control is exercised by the facility computers, with some control under the direction of operators from consoles. Stimulates processor
5. **Output data:** **Analog** (X) **Digital** ( )
6. **Target Information:**
   - a. **Number of targets** 15
   - b. **Are multiple targets available?** 6
   - c. **Number of discrete frequencies. (Lines)** 20
   - d. **List types of targets.** 12 targets, 3 own-ships

1. Snorkeling Sub	5. Fishing vessels	9. Hydrofoil ASW Craft
2. Battery Driven Sub	6. Destroyer	10. Small ASW Ships
3. Nuclear Powered Sub	7. Heavy Combatant Ship	11. Merchant
4. Surfaced Sub	8. Large Auxiliary	12. Light Cruiser

   - e. **Define line control (amplitude & frequency resolution.**

Discrete frequency lines are variable in amplitude from 0-75 db in 1 DB increments.

7. **List weapons simulated.** -4 sound generators are used to produce the basic types.

1. Steam Torpedo 4. Otto cycle engine(MK-48) 7. ____
2. High speed elec. Torpedo 5. ____ 8. ____
3. Low speed elec. Torpedo 6. ____ 9. ____

8. **List noises simulated.**

1. Marine Life (Tapes) 4. Carrier of UQC 7. ____
2. Sea-States, 0-6 5. ____ 8. ____
3. Torpedo Door 6. ____ 9. ____

9. **Oceans represented.** No oceans were specified.

1. ____ 3. ____ 5. ____
2. ____ 4. ____ 6. ____

10. **Define math model of propagation loss.**

The path and propagation loss effect is produced by a direct path propagation loss network, a bottom bounce path propagation loss network, and 2 deviation loss networks.

11. **List Sonar Systems and various displays.** AN/BQQ-2 System

(1) SKATE Class	(2) PERMIT Class
AN/BQG-3	AN/BQS-6B
AN/BQS-6B	AN/BQA-3
	AN/BQR-7
	AN/BQQ-3

ACOUSTIC SYNTHESIZER STUDY

1. Device /Facility 21A39 Trainer, NTEC
2. Year /Destination 1963/Charleston, S.C.
3. Description provides sonar room tactical team with conditions simulating all phases of operation that may be encountered aboard an SSBN 616 Class.
4. Input Control: Analog ( )
   Digital ( )
   Both (X)
5. Output data: Analog (X) Stimulates processor.
   Digital ( )
6. Target Information:
   a. Number of targets 9
   b. Are multiple targets available? 6
   c. Number of discrete frequencies. (Lines) 10
   d. List types of targets.

1. Merchant w/o cargo	5. Cruiser CA	9. Conventional Sub-Battery
2. Merchant with cargo	6. Destroyer DD	10.
3. Trawler	7. Nuclear Sub SSN	11.
4. Carrier CV	8. Conventional Sub-Diesel	12.

   e. **Define line control (amplitude & frequency resolution.**

Six Target Line Generators, one for each target, are used. Each TLG produces a line spectrum that simulates part of the frequency spectrum generated by machinery aboard the target. The line spectrum consists of 10 discrete frequencies, each generated by a VCO. Each VCO is modulated with a psuedo-random noise to produce a random jading effect. The levels of the modulated frequencies relative to each other are variable and contolled by a computer. Level: -10 to +30 db

7. **List weapons simulated.**

1.	Various Torpedoes	4.		7.	
2.		5.		8.	
3.		6.		9.	

8. **List noises simulated.**

1.	Marine Life	4.	Weapon explosions	7.	
2.	Variable Sea States	5.	Own ship noises	8.	
3.	Torpedo Door	6.	Reverberation	9.	

9. **Oceans represented.** No oceans were specified.

1.		3.		5.	
2.		4.		6.	

10. **Define math model of propagation loss.**

Acoustic meteorological oceanographic study. (AMOS). This math model was set up by NUSC from the AMOS studies.

11. **List Sonar Systems and various displays.**

AN/BQG-3

AN/BQS-4

AN/BQR-2

AN/BQR-7

ACOUSTIC SYNTHESIZER STUDY

1. **Device** /Facility Countermeasures Evaluator (CME) NCSL, Panama City
2. **Year** Installed 1968 with continuous modifications
3. **Description** R & D Facility for studying effects of counter measures on acoustic weapons and acoustic sensors.
4. **Input Control:**
   - **Analog** ( )
   - **Digital** ( )
   - **Both** (X)
5. **Output data:**
   - **Analog** (X)
   - **Digital** ( )
6. **Target Information:**
   - a. **Number of targets** 16
   - b. **Are multiple targets available?** Yes - variable
   - c. **Number of discrete frequencies. (Lines)** 70
   - d. **List types of targets.**

1.	Countermeasures	5.	Mines	9.	
2.	Surface Ships	6.		10.	
3.	Submarines	7.		11.	
4.	Torpedoes	8.		12.	

   - e. **Define line control (amplitude & frequency resolution.**

Target line noise characteristics are initially specified. They vary as a function of target speed and aspect angle. Discrete frequency lines are variable in amplitude from 0-127 db in 1 DB increments with line width variable from 0.2 HZ - 1.03 KHZ in 0.1 HZ increments.

7. **List weapons simulated.** Weapons processors are stimulated.

1.	4.	7.
2.	5.	8.
3.	6.	9.

8. **List noises simulated.**

1.	4.	7.
2.	5.	8.
3.	6.	9.

9. **Oceans represented.** As specified by BT.

1.	3.	5.
2.	4.	6.

10. **Define math model of propagation loss.**

CONGRATS or Model specified by customer. Sound attenuation along acoustic paths in the form of tabular data is prepared and used in real time by means of table look-up and tabular data.

11. **List Sonar Systems and various displays.**

AN/BQR - 2B

ACOUSTIC SYNTHESIZER STUDY

1. **Device** GNATS: General Noise & Tonal System
2. **Year** 1974 NUSC/New London
3. **Description** Decoy, Signal Synthesizer

4. **Input Control:**
   - **Analog** ( )
   - **Digital** ( )
   - **Both** (X) Panel knobs & read-only memories
5. **Output data:**
   - **Analog** (X)
   - **Digital** ( )
6. **Target Information:**
   - a. **Number of targets** Single
   - b. **Are multiple targets available?** No
   - c. **Number of discrete frequencies. (Lines)** 48
   - d. **List types of targets.** Signature is programmable.

1.		5.		9.	
2.		6.		10.	
3.		7.		11.	
4.		8.		12.	

   - e. **Define line control (amplitude & frequency resolution.**

Shaft A-16, Shaft B-16, Fixed programmable - 16. Amplitude: -10 db to +14 db in 16 steps of approximately 1 DB. Frequency resolution: Shaft A, B - 1/8 HZ; Fixed 1/16 HZ.

ACOUSTIC SYNTHESIZER STUDY

1. **Device** DASS: Digital Acoustic Synthesis System

2. **Year** 1974 NUSC/Newport, R.I.

3. **Description** Generates a complete acoustic signature of a submarine (or other vessel) including (1) radiated noise, (2) reflection of sonar pings.

4. **Input Control:**
   - **Analog** ( )
   - **Digital** (X) Acoustic control program in computer memory
   - **Both** ( )

5. **Output data:**
   - **Analog** (X)
   - **Digital** ( )

6. **Target Information:** "PASS" is passive portion of dual active/passive DASS

   a. **Number of targets** Single Signature Generator

   b. **Are multiple targets available?** No

   c. **Number of discrete frequencies. (Lines)** DASS(105), PASS(103)

   d. **List types of targets.** Could be programmed for any signature.

1.		5.		9.	
2.		6.		10.	
3.		7.		11.	
4.		8.		12.	

   e. **Define line control (amplitude & frequency resolution.**

PASS -64 Type A: Propulsion Lines

44 Type B: Auxiliary Lines

4 Type M: Cavitation lines

The phase relationship of harmonically related lines controllable with accuracy and resolution of 1° for $f \leq 1000$ HZ. Line frequency may vary as: step, ramp, exponential or random function.

ACOUSTIC SYNTHESIZER STUDY

1. Device 21A40 Trainer, Naval Training Equipment Center
2. Year 1974 - San Diego
3. Description Provides the sonar room tactical team with conditions that simulate all phases of operation on SSN585 and SSN635 classes.
4. Input Control: Analog ( ) Digital (x) Both ( )
5. Output data: Analog (x) Stimulates processor Digital ( )
6. Target Information:
   a. Number of targets 12
   b. Are multiple targets available? Yes (6)
   c. Number of discrete frequencies. (Lines) 20
   d. List types of targets.

1.	Diesel Electric Sub.	5.	Lt. Cruiser	9.	Trawler
2.	NUC Sub SSN & SSBN	6.	Patrol Craft	10.	Hydrofoil
3.	Destroyer	7.	Naval Auxiliary	11.	Aircraft
4.	Destroyer Escort	8.	Merchant	12	

   e. Define line control (amplitude & frequency resolution).

Target line noise characteristics include the effects of main engines, machinery, and props. They vary as a function of target speed and aspect. The discrete frequency lines are variable in amplitude from 0-75 db in one db increments with line widths variable from 0.15 Hz-12 Hz in 0.05 Hz increments.

7. List Weapons simulated.

1.	Torpedo MK 14, Steam Single speed	4.	Torpedo, Mk 45, Elec. 1 speed	7.	
2.	Torpedo Mk 16, steam 1: speed	5.	Torpedo, Mk 48 Variable speed	8.	
3.	Torpedo Mk 37 Electric 2 speed	6.	Subroc - Rocket	9.	

8. List Noises simulated.

1.	Marine life	4.	Weapon explosions	7.	Volcano
2.	Rain	5.	Anchor chains of buouy	8.	
3.	Surface ship gunfire	6.	Ice Pack (10 mi dia)	9.	

9. Oceans represented.

1.	Mid Pacific	3.	Sea of Japan	5.	
2.	Northern Pacific	4.	Southeast Asia	6.	

10. Define math model of propagation loss. FACT (Fast Asymptotic Coherent Transmission)

11. List Sonar Systems

Attack Center #1	Attack Center #2
AN/BQS-6	AN/BQR-2
AN/BQR-7	AN/BQS-4
AN/BQQ-3	AN/BQG-4
AN/BQR-20	AN/BQR-20

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